ARMY RESEARCH LABORATORY

Night Vision Goggles (NVG) Software User's Guide Version 5.1

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Numerous military applications utilize night vision devices (NVD). Aviation and ground transportation are two applications that Night Vision Goggles (NVG) is intended to support. Aviators and vehicle drivers must have an idea of what the ambient light levels are before using NVD's. Not enough light precludes safe use of the devices, while enough light allows for adequate performance of the required tasks by the unaided eye. The weather also effects natural illumination. NVG is intended to provide users of NVD's with forecasts of favorable and unfavorable times of use. The criteria for NVD use times are specified by the user in terms of lunar altitude and percent illumination as well as illumination level to ensure wide application of the software in terms of the different NVD's and different services. The illumination level for user specified times can also be determined. Current or forecast meteorological conditions or climatology may be input to realistically account for the effects of clouds, fog, precipitation, and surface reflectivity. The user friendly program is menu driven for ease of operation.

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1. Introduction

Night Vision Goggles (NVG) User's Guide is an update to Atmospheric Sciences Laboratory Internal Report *Nightvis User's Guide*, February 1990. A number of enhancements have been made based on user feedback. *NVG User's Guide* is for version 5.1 of the NVG Software.

NVG is a computer program developed on a Zenith 286 microcomputer system and written in Turbo Pascal under the Microsoft-Disk Operating System (MS-DOS) version 3.2. The software package is capable of execution on IBM PC compatible machines. It provides guidance on the times of night vision device (NVD) use and nonuse based on a set of user specified criteria (light level planning calendar (LLPC) option). The illumination level for user specified times may also be determined (illumination calculation (Illum) option). Also included within the package are the daily event times (EVNT) and solar and lunar position chart options. NVG is unique in that meteorological effects (i.e., fractional clouds, precipitation, and fog) on the natural illumination are accounted for in a realistic manner. Thus, the limiting assumption of clear sky need no longer be adhered to.

NVG is based largely on two existing algorithms: (1) routines to determine solar and lunar locations and lunar phase are based on the "ILLUM" model developed by van Bochove; [1] and (2) routines accounting for the attenuation of incoming illumination are based on an algorithm by Shapiro. [2] NVG output should be valid for approximately 20 years beginning in 1994. Solar and lunar positions will be within a few minutes of arc for several years after 1994, then will become progressively less accurate for the ensuing years. By the year 2010, positions of the moon may be off by a full degree or more depending on the geographic location for which the program is run. Current output is valid for locations equatorward of approximately 60° north or south latitude. For latitudes poleward, multiple daily lunar risings and settings and periods for which the sun and moon approach but do not cross the horizon, preclude accurate predictions of solar and lunar rise and set times. The software does not take into account the effect of terrain (e.g., mountains) on solar and lunar rise and set times or on illumination values caused by shadowing effects.

A version of NVG is furnished on a single 3.5- or 5.25-in. floppy diskette with the executable code and data files. The executable program does not require a math coprocessor. For minimal runtime, all the included files should be loaded onto the hard disk rather than executed from the floppy. All software is automatically loaded onto the hard disk C by the install program on the floppy. The current runtime for a month time period is approximately 3 min on a Unisys 386 utilizing a Unisys dot matrix printer. A printer capable of printing 12 characters per inch (cpi) or greater or that can print more than 80 columns of 10 cpi is required.

Detailed technical documentation is not provided here. For detailed technical documentation of the program, see Duncan and Sauter. [3]

Only natural illumination sources (i.e., the moon and stars, and also the sun for the Illumination Calculation option) are considered in NVG. No artificial light sources are incorporated. Contributions from nearby light sources (such as populated areas, vehicle lights, etc.) are not accounted for. When flying in the vicinity of artificial light sources, the ambient illumination level will probably be greater than predicted by the model; therefore, output may not be valid.

2. Program Execution

2.1 Start

To install NVG onto the hard drive, select the drive containing the floppy. Type <INSTALL> to copy the necessary files to a subdirectory named NVG. (Note: It is necessary to have a hard disk designated as C.) Return to the C:\ prompt. The NVG subdirectory should now be the current directory. (Note: If the software has already been installed, change the directory to the NVG subdirectory.) Type <NVG> and press <return>. An animated introduction screen is displayed. Press <space> to continue. A header appears on the screen explaining the purpose of NVG. Press <return> after reading the header.

2.2 Menu Items

The menu in figure 1 lists the available options for NVG.

```
  ┌───Night Vision Goggles Application──────┐
  │                                         │
> > eXit                                    │
  │ Select classification                   │
  │ Light level planning calendar[LLPC]     │
  │ Illumination calculation[Illum]         │
  │ daily Event times [EVNT]                │
  │ solar and lunar Position Chart          │
  │                                         │
  └──────Select or ? for Help───────────────┘
```

Figure 1. NVG Application menu.

Note: To select an option, enter the highlighted, capitalized letter or use the arrow keys to select an option by moving the > > prompt on the left side of the menu.

When editing a parameter, press <return> to abort the editing process and save the current value of the variable.

2.2.1 Exit Option

Selecting the exit option terminates program execution.

2.2.2 Select Classification Option

After selecting this option, notice that the option becomes highlighted. A prompt on the bottom of the screen requires entry of the type of classification for this particular application. The following options are currently available:

(N)one, (U)nclassified, (F)OUO, (C)onfidential
(S)ecret, SecretN(O)FORN, (T)op Secret

Enter the corresponding letter and press <return>. Note: NVG output itself is unclassified.

2.2.3 Light Level Planning Calendar [LLPC] Option

Selection of the LLPC option creates the menu shown in figure 2.

```
  ┌─────────Site/Date Information──────────────┐
  │                                             │
> >Station Latitude             32  10  N
  │ Station Longitude          106  45  W
  │ Station ID                 WSMR, NM
  │ Year                          1992
  │ START:
  │    Month                      June
  │    Day                         30
  │ END:
  │    Month                      July
  │    Day                          1
  │ Continue
  │                                             │
  └─────────Select or ? for Help───────────────┘
```

Figure 2. Site/Date Information menu.

2.2.3.1 *Station Latitude Entry.*-- After selecting Station Latitude, a message appears at the bottom of the screen listing the current latitude. To enter a new value, insert the value in the format DDMMd: DD must be a 2 digit degree (≥ 0 and ≤ 64), MM must be the 2 digit minute (≥ 0 and ≤ 60), and d must be the hemisphere (either (N)orth or (S)outh). Invalid entries will not be accepted, and a prompt to enter a valid value will appear. Note: If DD is < 10, enter a leading 0 (i.e., for 9° 30' north latitude, enter <0930n> or <0930N>).

2.2.3.2 *Station Longitude Entry*.-- The Station Longitude entry operates like the Station Latitude as explained above. Enter leading 0's if longitude is < 100.

2.2.3.3 *Station ID Entry*.-- The Station ID entry does not affect program output. It is simply a tag used to identify output. Enter up to 12 alphanumeric characters.

2.2.3.4 *Year Entry*.-- The Year entry is a four digit integer used to start and end program computations. For greatest accuracy, this value should be > 1993 but < 2014.

2.2.3.5 *Start Month Entry*.-- The Start Month entry assigns the month for the program computations to begin. It also flags the month for which climatology (2.2.3.9.5 and 2.2.3.9.8) will be used if the climatology option is selected. Enter the 1 or 2 digit number of the month for which the program will begin to run. Leading 0's are not required if the month is < 10. Entries are error trapped for values ≤ 0 and > 12.

2.2.3.6 *Start Day Entry*.-- The Start Day entry assigns the day in the assigned start month for the program computations to begin. Start day and start month are the date to be used for the Illumination Calculation if this option is chosen (2.2.4). If the day is < 1 or > the number of days in the start month, a prompt to reenter the value will appear. Leading 0's are not required.

2.2.3.7 *End Month Entry*.-- See 2.2.3.5. The End Month entry assigns the month for the program computations to end. The end month must be ≥ start month. The End Month entry is ignored if the Illumination Calculation option is chosen (2.2.4).

2.2.3.8 *End Day Entry*.-- See 2.2.3.6. The End Day entry assigns the day in the assigned end month for the program computations to end. The end day must be > the start day if the end month = the start month. The End Day entry is ignored if the Illumination Calculation option is chosen (2.2.4).

2.2.3.9 *Continue Option (Weather/Goggle Information Menu)*.-- Select the Continue option only after editing the variables in the Site/Date Information menu.

The Continue option introduces the Weather/Goggle Information menu shown in figure 3.

```
┌──────────Weather/Goggle Information──────┐
│ NVG USE CRITERIA:                        │
> >        Illumination           2.50 MLX │
│          Min lunar alt            30 DEG │
│          min Lunar illum %        23 %   │
│ METEOROLOGY:                             │
│          clear Sky                 X     │
│          Climatology                     │
│          Overcast                        │
│          User specified                  │
│          View/change climatology         │
│ return to Previous menu                  │
│ Run                                      │
│ Quit to Main Menu                        │
│                                          │
└────────────Select or ? for Help──────────┘
```

Figure 3. Weather/Goggle Information menu.

Use and nonuse criteria are different for the PVS-5 and ANVIS devices; these differences can be accounted for in the model. When only clear sky conditions could be modeled, the 23 percent/30° criteria was acceptable; however, now that more complicated meteorological scenarios can be modeled, this criteria may be of little use. The reason for this is that as cloud amount and thickness increase to the point at which most of the lunar illumination is obscured, it does not matter what percent of the moon is illuminated or how high in the sky it is. The point at which this criteria becomes unacceptable (in terms of cloud amount and cloud height (i.e., type)) is arbitrary. As a result, there is no default cutoff criteria in NVG at which the night vision use and nonuse criteria switch over to being based on an absolute illumination value. Each time the software is used, the limit may be set.

If the criteria for using the NVD's is based on lunar altitude and percent illuminated as well as an absolute illumination value, set the three parameters to the desired values in the Weather/Goggle Information menu. If cloudiness is great enough that the lunar altitude and percent illuminated criteria are no longer valid (or if the user wants NVD use and nonuse times based strictly on the illumination level regardless of cloud amount), set the Min lunar alt under the NVG Use Criteria header in the Weather/Goggle Information menu to 90°. Similarly, set the Min lunar illum % to 100 percent. Because the probability of the lunar altitude being equal to 90° and the percent illuminated being equal to 100 simultaneously on a particular 15 minute interval (the time step in NVG) is remote, the chances of the lunar altitude and the percent illuminated criteria being met are equally remote. Thus, only the absolute illumination value criteria can be met. In this instance the ., X, and O characters represent nonuse times of NVD's and blank spaces represent times of use.

1. Illumination Entry. The Illumination entry sets the minimum illumination level determined safe for use of NVD's. Enter the value (which must be a positive number) and units. Entries must be positive numbers. Valid units are lux (<L> or <l>), millilux (<M> or <m>), or footcandles (<F> or <f>). Do not enter any spaces between the value and its units (e.g., enter 3 millilux as <3M> or <3m>). The units selected for the Illumination entry also will be used for the Illumination Calculation option described further in 2.2.4. Note: This illumination criteria is not to be confused with the Illumination Calculation option as described in 2.2.4.

2. Min Lunar Alt Entry. The Min Lunar Alt entry sets the minimum lunar altitude determined safe for use of NVD's. Enter degrees above the horizon.

3. Min Lunar Illum % Entry. The Min Lunar % entry sets the minimum lunar illumination in percent of the full lunar face determined safe for use of NVD's. Valid entries are ≥ 0 and ≤ 100.

Under the Meteorology header there are five choices. Based on the header selected, pertinent meteorological variables affecting the illumination level are assigned. These variables are cloud amounts in the 3 levels of the model, cloud type in the highest level, and surface albedo.

4. Clear Sky Entry. The Clear Sky entry assigns zero percent clouds in all three model cloud levels. Surface albedo does not affect output for clear sky.

5. Climatology Entry.-- The Climatology entry assigns cloud amounts and surface albedo as stored in the existing data file CLIMO.DAT for the start month in effect (see 2.2.3.5). To view or change the current climatology values, select 2.2.3.9.8. If using this option for the first time, it is necessary to select 2.2.3.9.8 and change the current default climatology values to valid values for the current location.

Note: If current location is in southeast Alabama, changing the climatology should not be necessary, as the only values entered are for Ft. Rucker, AL.

6. *Overcast Entry*. The Overcast entry assigns 100 percent clouds in the three cloud layers of the model. Surface albedo is equal to the dry surface (0.20, 20 percent).

7. *User Specified Entry*. Selecting the user specified entry results in a new submenu (figure 4) with the pertinent meteorological variables to be edited.

```
 ┌─────Meteorological Information─────┐
 │                                    │
 │  CLOUD COVER:                      │
>>         Layer1           8050      │
 │         Layer2           8080      │
 │         Layer3           8100      │
 │         Layer4           8250      │
 │   Visibility            50000      │
 │   Weather                   2      │
 │   Surface type              0      │
 │   EXIT                             │
 │                                    │
 └───────Select or ? for Help─────────┘
```

Figure 4. Meteorological Information menu.

Four cloud levels are listed although the model can utilize only three cloud layers (low, middle, and high). Four levels are listed to make it less likely to leave off a reported cloud deck. The program has an algorithm to assign cloud fractions in the three layers based on the cloud amount and height reported in the four levels. Cloud type is a variable only for cirrus (thick or thin). Stratocumulus is the low level cloud, altostratus and altocumulus the midlevel cloud, and thick or thin cirrus the high level cloud. The four digit cloud code is based on conversations with personnel at Ft. Rucker. The first digit represents cloud amount in eighths, and the second through fourth digits represent the cloud height in hundreds of feet (enter a 5/8 cloud at 5000 feet as <5050>). To differentiate thin from thick cirrus, enter a "-" after the 4 digit high cloud code with no spaces between the last cloud height digit and "-" (enter a 6/8 thin cirrus at 25,000 feet as <6250->, and a 6/8 thick cirrus at 25,000 feet as <6250>).

Visibility does not have any effect on program output.

The weather coontains the following options:

0. Any Precipitation
1. Fog/Haze
2. Other/None

Fog is a special case for which specific low cloud radiative properties are assigned if there is no overcast low or middle cloud or if the overcast is a high cloud (thin or thick cirrus). This is based on empirical data cited by Shapiro. [2] If the fog obscures the sky, the low cloud layer should be treated as a low cloud overcast and entered as such (e.g., <8005>).

Precipitation also is a special case. Because the physics of precipitation particles are not modeled directly, this case is represented by complete overcast in all three cloud levels.

Surface type is used to assign an albedo (ratio of incoming radiation reflected off the earth's surface). The surface types available for runtime are as follows:

0. Desert	4. Crops
1. Salt flat	5. Snow $<$ 1/2
2. Forest, deciduous	6. Snow $\geq$ 1/2
3. Forest, coniferous	7. Soil, dark

8. View/Change Climatology. Selecting the View/Change Climatology entry displays the current monthly climatological values for the start month. If the values are correct, exit this submenu. If the values are incorrect, edit the values as discussed in 2.2.3.9.7. The changes will be saved in the data file CLIMO.DAT upon exiting the submenu and will become the new climatology for the current start month. To run the program for meteorological values other than those specified in the Climatology option but not save the values, use the User Specified option instead.

9. Run Option. Once all parameters have been edited, select 'EXIT' to return to the previous menu. Select the Return to Previous Menu option to edit the nonmeteorological values. Select the Run option to execute the program for the selected values. If the Run option is selected, the menu will be erased, and a prompt will appear before the program runs. For the Light Level Planning Calendar option, the prompt is the time difference, in hours, between current local time and Greenwich Mean Time (GMT). Only the absolute value of this difference is required, as the program uses the longitude (west or east) to determine if the value should be positive or negative. Integer values $\geq$ -1 and $\leq$ 12 are valid entries. If the time difference is unknown, input -1. A message is displayed stating that an estimate of the time difference will be made based on site longitudes, not time zones. Upon entry of the time difference, a header will print.

Make sure the printer is on and extra wide paper is installed. If using 8 ½-in.-wide paper, set the pitch to 15 or greater. Press <esc> at this point to bypass the printer output. A short header will also be displayed on the screen. A bar depicting the total run time of the program appears beneath the header. As the program progresses, the bar will decrease in size in proportion to the remaining run time. It is possible to execute multiple cases prior to exiting.

A menu (figure 5) will appear containing the graphic options.

```
    ┌──────Graphic Options──────┐
    │                           │
  > >  Quit to nvg main menu    │
    │  Select Printer           │
    │  graph Bar chart          │
    │  graph Line chart         │
    │  graph Altitude chart     │
    │  graph Azimuth chart      │
    │                           │
    └─────Select or ? for Help──┘
```

Figure 5. Graphic Options menu.

A. Select Printer Option. The Select Printer option enables a printer type to be loaded to create screen dumps of the graphic option outputs. The following printers are included:

1. HP LaserJet Series
2. IBM/Epson
3. Epson

Note: One of the printers must be selected before executing any graphics options. During graphics screen displays, press <P> to print, or press any key to continue.

B. Graph Bar Chart Option. The Graph Bar Chart option generates a bar chart of favorable, marginal, and unfavorable times for NVG for current conditions. For multiple day use (maximum of 16 days), a second menu appears containing the current mission dates. Select the number that corresponds to one of the dates listed, and calculations will proceed for the specified date (figure 6). The first bar represents the natural illumination criteria. The second bar represents the Lunar % and Lunar altitude criteria. The third bar represents the combination of the first two bars. The bars indicate times of favorable, marginal, and unfavorable NVD use. The caution bar is calculated as ± 10 percent of the user specified criterion. Press <P> to print the graph. Press any other key to continue.

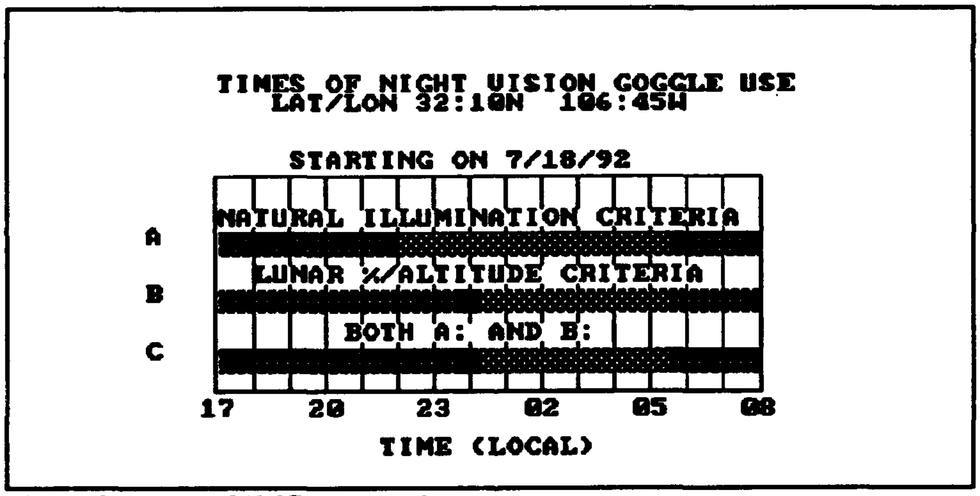

Figure 6. Times of NVG use bar chart.

C. Graph Line Chart Option. The Graph Line Chart option generates a line chart of use and nonuse times for NVG. For multiple day use (maximum of 16 days), a second menu appears containing the current mission dates. Select the number that corresponds to one of the dates listed, and calculations will proceed for the specified date (figure 7). The line chart consists of a curve that traces natural illumination for current meteorological conditions. The line chart is more complicated than the bar chart, but it gives more information. The line chart shows the level of illumination throughout the evening, nighttime, and morning hours. Approximate times of sunrise, moonrise, sunset, and moonset can be inferred from the illumination curve. Press <P> to print the graph. Press any other key to continue.

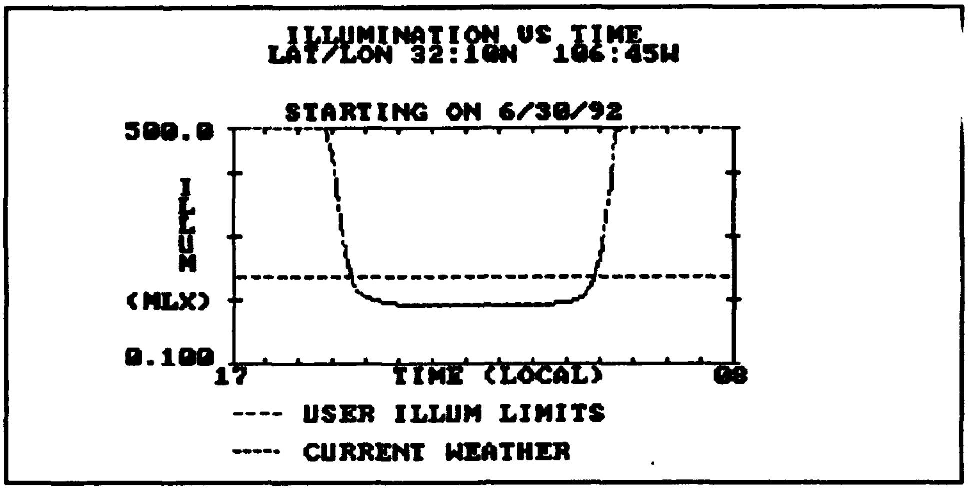

Figure 7. Illumination versus time line chart.

D. Graph Altitude Chart Option. The Graph Altitude Chart option generates a line chart of lunar altitude versus local time. For multiple day use (maximum of 16 days), a second menu appears containing the current mission dates. Select the number that corresponds to one of the dates listed, and calculations will proceed for the specified date (figure 8). The chart consists of a curve that traces the lunar altitude above or below the horizon (in degrees). A horizontal line is drawn across the chart denoting 0° altitude (i.e., the horizon) such that the time of lunar rise and set can be readily seen. Press <P> to print the graph. Press any other key to continue.

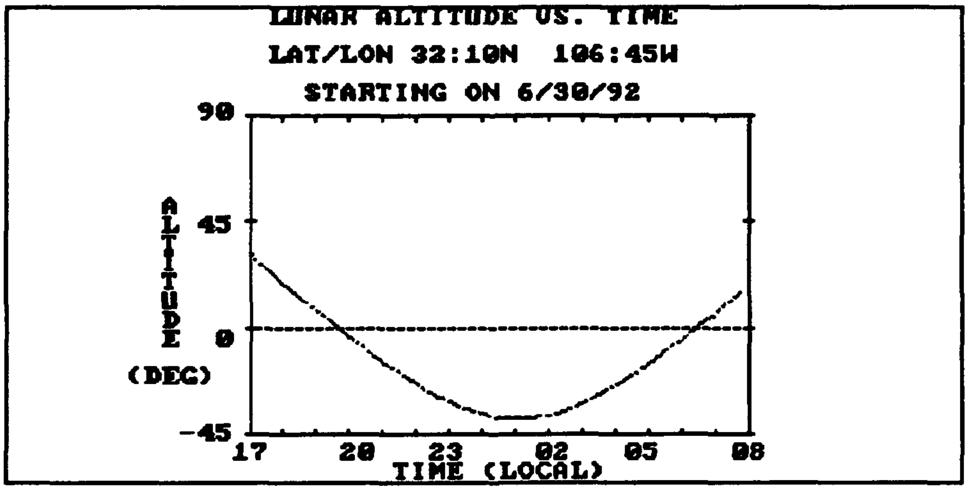

Figure 8. Lunar altitude versus time line chart.

E. *Graph Azimuth Chart*. The Graph Azimuth Chart option generates a line chart of lunar azimuth versus local time. For multiple day use (maximum of 16 days), a second menu appears containing the current mission dates. Select the number that corresponds to one of the dates listed, and calculations will proceed for the specified date (figure 9). The chart consists of a curve that traces the lunar azimuth (in degrees clockwise from north). Press <P> to print the graph. Press any other key to continue.

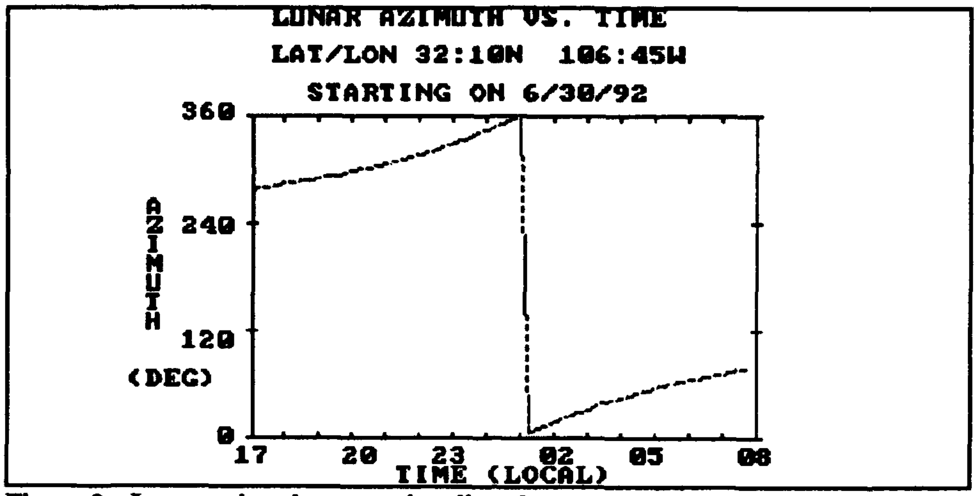

Figure 9. Lunar azimuth versus time line chart.

Also note that output of moonrise and moonset times are stored in an ASCII text file named moonfile.txt on the hard disk (NVG directory).

2.2.4 *Illumination Calculation [Illum] Option*

Execution of the Illumination Calculation option requires procedures similar to those described in the Light Level Planning Calendar option. When Run is selected, a prompt asks for the GMT. The integer value must be > 0 and < 2359. The first two digits represent the hour, and the last two digits represent the minutes. Leading zeroes are not required (enter a GMT of 0007 as <7>). The minutes entry must be ≥ 0 and ≤ 60. Press <P> to print. Press <space> to continue. It is possible to execute multiple cases before exiting this option.

2.2.5 *Daily Event Times [EVNT] Option*

Execution of the Daily Event Times option requires procedures similar to those described in Light Level Planning Calendar option. Meteorological inputs do not affect the output of the Daily Event Times option. When Run is selected, a prompt asks for the difference between site local time and GMT. Integer values from 0 to 12 and -1 are valid inputs. Times of beginning morning nautical twilight (sun 12° below horizon), beginning morning civil twilight (sun 6° below horizon), sunrise, sunset, ending evening civil twilight, and ending evening nautical twilight will be displayed. The information is displayed for the days specified by the operator. Press <P> to print. Press <space> to continue. It is possible to execute multiple cases before exiting the Event Times option.

Also, note that output is stored in an ASCII text file named event.txt on the hard disk (NVG directory).

2.2.6 Solar and Lunar Position Chart Option

Execution of the Solar Lunar Position Chart option requires procedures similar to those described in Light Level Planning Calendar Option. When Run is selected, a prompt asks for the units of illumination. A second prompt appears that requires the difference in site local time and GMT to be entered. Integer values from -1 to 12 are valid inputs. Alphanumeric display of solar and lunar azimuth, altitude, illumination, and lunar phase at 15-min intervals for as many days that are specified by the operator. Press <P> to print. Press <space> to continue. It is possible to execute multiple cases before exiting this option.

3. Explanation of Output

3.1 Light Level Planning Calendar Output

The Light Level Planning Calendar output is graphical and alphanumeric. An alphanumeric sample is replicated in figure 10.

```
     **** Light level planning calendar for WSMR, NM with weather conditions as listed ****
               Latitude N 32 degrees 10 minutes  Longitude W 106 degrees 30 minutes
 ---------------------------------------------------------------------------------------------------------
                                   Meteorological Conditions:
                                         Cloud Layer 1      0
                                         Cloud Layer 2      0
                                         Cloud Layer 3      0
                                         Cloud Layer 4      0
                                         Visibility     10000 m
                                   State of Ground    Dry
                                 Significant Weather   None

                                     1  FEB 1990  TO  15  FEB 1990
 For     Moon  Sun  %Mn@  17  18  19  20  21  22  23  00  01  02  03  04  05  06  07  08  For  Moon  Sun
 PM on   R/S   set  2400   !   !   !   !   !   !   !   !   !   !   !   !   !   !   !   ! AM on  R/S  rise
  1 FEB   **   1737  44%   ...---------------         000XXXXXXXXXXXXXXXXXXXXXXXXXX...  2 FEB S  16  655
  2 FEB  R1056 1738  55%   ...-------------------          00XXXXXXXXXXXXXXXXXXXXXX...  3 FEB S 126  655
  3 FEB  R1141 1739  66%   ...-----------------------           0XXXXXXXXXXXXXXXXXX...  4 FEB S 235  654
  4 FEB  R1234 1740  77%   ...---------------------------           0XXXXXXXXXXXXX....  5 FEB S 340  653
  5 FEB  R1334 1741  86%   ...-------------------------------          0XXXXXXXXX....  6 FEB S 439  653
  6 FEB  R1440 1741  93%   ...-------------------------------------         XXXXXX....  7 FEB S 529  652
  7 FEB  R1547 1742  97%   ...    ------------------------------------         XXX....  8 FEB S 611  651
  8 FEB  R1653 1743 100%   ...        -----------------------------------        X....  9 FEB S 647  650
  9 FEB  R1757 1744 100%   ...XX          ---------------------------------        .... 10 FEB S 718  649
 10 FEB  R1857 1745  98%   ...XXXXXX          -------------------------------      .... 11 FEB S 747  649
 11 FEB  R1955 1746  93%   ...XXXXXXXXX0          ----------------------------     .... 12 FEB S 813  648
 12 FEB  R2052 1747  87%   ...XXXXXXXXXXXXX0         -------------------------     .... 13 FEB S 840  647
 13 FEB  R2148 1748  80%   ....XXXXXXXXXXXXXXXX0         ----------------------    .... 14 FEB S 907  646
 14 FEB  R2245 1749  72%   ....XXXXXXXXXXXXXXXXXXXX0        --------------------.... 15 FEB S 937  645

 Date     R/S  Sun  %Mn@   !   !   !   !   !   !   !   !   !   !   !   !   !   !   !   !  Date   R/S  Sun
          Moon set  2400  17  18  19  20  21  22  23  00  01  02  03  04  05  06  07  08        Moon rise

 (....) indicates Sun above horizon
 (XXXX) indicates Moon below horizon
 (----) indicates the Moon is at least 23 percent illuminated and at least 30 degrees above the
        horizon
 (    ) indicates Mnlite & Starlite greater than or equal to 0.0025 lux but moon not 23%
        illuminated or not 30 deg above horizon
 (0000) indicates Mnlite & Starlite Level less than 0.0025 lux and moon not 23% illuminated or
        not 30 deg above horizon or neither

  ************** Data provided by U.S. Army Research Laboratory, BE Directorate **************
```

Figure 10. Light Level Planning Calendar output.

The first 10 lines of figure 10 are a summary of input information furnished by the user. The information helps identify the output for future reference. Below the first 10 lines is an output header giving the dates of the program run and a list of local time from hours 17 through 08 the following day.

Below the heading "For PM on" are the month and day for which the output begins. Below "Moon R/S" is the local time of the moonrise or moonset for that day. Below "Sun set" is the time of sunset. Below "% Mn @ 2400" is percent of the moon illuminated at 2345 local time. Following several blank spaces of output is a string of characters decoded per the key at the bottom of the output page. A single "." indicates that the sun is above the horizon for the corresponding time vertically above and below the character. Each hour is divided into four 15-min periods, with the "!" character representing the top of the hour (i.e., 1700, 1800, etc.). If the "." were located one character space to the right of the "!", it would represent 15 minutes past the hour. Correspondingly, two character spaces to the right represent 30 minutes past the hour. An "X" indicates the moon is below the horizon. A "-" indicates the moon is at least the min lunar percent illuminated (2.2.3.9.3) and at least the min lunar altitude above the horizon (2.2.3.9.3). A " " indicates that moonlight + starlight is ≥ the illumination (2.2.3.9.1), and the moon is not the min lunar percent illuminated (2.2.3.9.3) nor the min lunar altitude above the horizon (2.2.3.9.2). "0" indicates that the moonlight + starlight level is < the illumination (2.2.3.9.1), and the moon is not the min lunar percent illuminated (2.2.3.9.3) nor the min lunar altitude above the horizon (2.2.3.9.2). The important factors influencing NVD use and nonuse times can be quickly assimilated for daily intervals over an extended period of several days, weeks, or months.

3.2 Illumination Output

Output for the Illumination Output option appears on the PC console. Press <P> at the prompt to print. A sample is replicated in figure 11.

```
******************** Illumination for: ********************
     *   WSMR, NM with weather conditions as listed   *
Latitude N 32 degrees 10 minutes  Longitude W 106 degrees 45 minutes
_____________________________________________________________________

                 Meteorological Conditions:
                   Cloud Layer 1   5050
                   Cloud Layer 2      0
                   Cloud Layer 3      0
                   Cloud Layer 4      0
                   Visibility     10000 m
                   Surface Type   Desert
                Significant Weather   None

                  0800Z    20 JUNE 1992
                 ILLUMINATION = 18.1 MLX
           Lunar Altitude above horizon = 29.8 deg
      Lunar Azimuth = 125.4   Face Illuminated = 77.1%
```

Figure 11. Illumination output.

A header appears at the top of the screen describing the purpose of the computation. The three lines below the header display the alphanumeric location as well as geographic location (latitude and longitude). The next eight lines display the meteorological conditions specified by the user earlier in the program. The last four lines display the GMT, date of the Illumination Calculation, illumination value, lunar altitude (a negative value represents the moon below the horizon), lunar azimuth, and percent of the lunar face illuminated.

The program uses the natural illumination level during computation as a function of meteorological conditions, geographic location, and time.

3.3 Event Times Output

Output for the Event Times Output option appears on the PC console. Press <P> at the prompt to print. A sample is replicated in figure 12.

**************** Event times for WSMR, NM ****************

Latitude N 32 degrees 10 minutes Longitude W 106 degrees 45 minutes

15 JUNE 1992 to 30 JUNE 1992

	BMNT	BMCT	SRISE	SSET	EECT	EENT
15 JUN	458	533	559	2014	2039	2114
16 JUN	458	533	559	2014	2040	2114
17 JUN	458	533	559	2015	2040	2114
18 JUN	459	533	559	2015	2040	2115
19 JUN	459	533	559	2015	2040	2115
20 JUN	459	533	559	2015	2041	2115
21 JUN	459	534	600	2016	2041	2116
22 JUN	500	534	600	2016	2041	2116
23 JUN	500	534	601	2016	2042	2116
24 JUN	501	534	601	2016	2042	2116
25 JUN	501	535	601	2016	2042	2116
26 JUN	501	535	602	2016	2042	2116
27 JUN	502	535	602	2016	2042	2116
28 JUN	502	536	602	2016	2042	2116
29 JUN	502	536	603	2017	2042	2117
30 JUN	503	537	603	2017	2043	2117

Figure 12. Event times output.

A header appears at the top of the screen describing the purpose of the computation. The lines after the heading describe the testing site location and the period for which the test was run. The computed values for the beginning nautical time (BMNT), beginning civil time (BMCT), sunrise (SRISE), sunset (SSET), ending evening civil time (EECT) and ending evening nautical time (EENT) are shown for the respective day.

3.4 Solar and Lunar Position Output

Output for the Solar and Lunar Output option appears on the PC console. Press <P> at the prompt to print. A sample is replicated in figure 13.

************** Solar and Lunar Position Chart**************

Lat 32 10 N   Lon 106 45 W

Times are local starting on 30 JUN 92

	SOLAR		Illum.	LUNAR		%Moon	Illum.
Time	Azimuth	Altitude	(MLX)	Azimuth	Altitude	(phase)	(MLx)
1700	282	27	30051076	276	31	0	0.64
1715	283	24	25562282	278	28	0	0.64
1730	285	21	21337059	280	25	0	0.64
1745	287	18	16546657	281	22	0	0.64
1800	288	15	12177047	283	19	0	0.64
1815	290	12	9297062	284	16	0	0.64
1830	292	9	6673542	286	13	0	0.64
1845	294	6	4007712	288	10	0	0.64
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.

Figure 13. Solar and lunar position chart output.

A header appears at the top of the screen describing the purpose of the computation. The lines after the header describe the testing site location and the period during which the test was run. The computed values for the solar and lunar azimuths, altitudes, illuminations, and lunar phase are displayed for 15-min intervals.

4. Summary and Discussion

NVG is an easy to run computer program developed at the U.S. Army Research Laboratory, Battlefield Environment Directorate as an aid for determining favorable, marginal, and unfavorable times for NVD use. This program runs in realistic time (about 2.5 min for a monthly simulation period on an IBM PC compatible 386 MHz machine) and incorporates meteorological effects on the natural illumination. Artificial light sources are not included. Selecting the Illumination Calculation option produces an estimate of the illumination for a user specified time in a few seconds.

Comparisons of model output to actual measurements of nocturnal illumination indicate agreement. [3] Comparison of moonrise and moonset times to actual event times in *The Astronomical Almanac* (tables 1 and 2) [4] show excellent agreement for low and mid latitudes. At higher latitudes, discrepancies begin to appear (section 1). Accurate predictions could also be attained at high latitudes with a sacrifice in run time by modifying the code.

NVG should provide valuable guidance for determining training periods using NVD's keeping in mind the following facts:

(1) Artificial light sources are not included. When near artificial light sources, actual illumination levels may be significantly greater than predicted by NVG.

(2) Shadow effects are not modelled. When in shadows (of mountains, ridges, etc.), the direct source of illumination is cut off. Depending on the phase and altitude of the moon, shadows may significantly reduce the illumination level below the level predicted.

(3) When using partly cloudy conditions as input to NVG, remember that model output is for an average of the moon being obscured and not obscured by clouds. When the moon is behind a cloud, actual illumination is probably less than the illumination predicted. When the moon is not obscured, the actual illumination is likely to be greater than the illumination predicted.

Table 1. Comparison of NVG to almanac event times (April)

1988
20° N 0° W

Date	NVG Moonrise	Almanac Moonrise	NVG Moonset	Almanac Moonset
April 1	1740	1740	0515	0515
April 2	1830	1830	0546	0546
April 3	1922	1922	0619	0619
April 4	2017	2017	0655	0654
April 5	2115	2115	0735	0735
April 6	2216	2216	0821	0820
April 7	2317	2317	0913	0912
April 8	NONE	NONE	1011	1011
April 9	0017	0017	1114	1114
April 10	0113	0112	1219	1219
April 11	0203	0203	1324	1324
April 12	0248	0248	1427	1427
April 13	0330	0329	1529	1528
April 14	0409	0409	1629	1629
April 15	0447	0447	1729	1729

Table 2. Comparison of NVG to almanac event times (January)

1988
50° N 0° W

Date	NVG Moonrise	Almanac Moonrise	NVG Moonset	Almanac Moonset
Jan 15	0419	0420	1206	1206
Jan 16	0540	0542	1248	1247
Jan 17	0655	0655	1349	1349
Jan 18	0752	0752	1509	1509
Jan 19	0832	0833	1642	1642
Jan 20	0900	0900	1817	1817
Jan 21	0921	0921	1949	1948
Jan 22	0937	0937	2116	2115
Jan 23	0951	0951	2139	2139
Jan 24	1005	1005	NONE	NONE
Jan 25	1020	1020	0001	0001
Jan 26	1037	1037	0121	0121
Jan 27	1059	1100	0241	0241
Jan 28	1128	1129	0358	0357
Jan 29	1208	1208	0508	0507
Jan 30	1259	1259	0607	0606
Jan 31	1401	1401	0652	0651

Comments, questions or suggestions on NVG should be addressed to:

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Battlefield Environment Directorate
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White Sands Missile Range, NM 88002-5501

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Acronyms and Abbreviations

ASCII	Amercian Standard Code for Information Interchange
BMCT	beginning civil time
BMNT	beginning nautical time
cpi	characters per inch
EECT	ending evening civil time
EENT	ending evening nautical time
EVNT	daily event times
GMT	Greenwich Mean Time
Illum	illumination calculation
LLPC	light level planning calendar
MS-DOS	Microsoft-Disk Operating System
NVD	night vision device
NVG	Night Vision Goggles
SRISE	sunrise
SSET	sunset

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